THE MARINER 7 INFRARED SPECTRA: CALIBRATION AND A PREVIEW FOR TES

G. Cimino *Astrophys. Obs.,Univ. Catania, Catania, Italy, gcimino@alpha4.ct.astro.it* and W. M. Calvin *U. S. Geological Survey, Flagstaff, AZ 86001, USA,wcalvin@flagmail.wr.usgs.gov*

We have performed a refined radiometric and wavelength calibration for selected spectra from the Mariner 7 Infrared Spectrometer (IRS) data set. The Mariner 7 spacecraft flew by Mars on August 5, 1969 (L_s=200°, early southern spring). The spectra obtained by the spectrometer covered primarily equatorial to mid-southern latitudes, with one strip extending from -45° to -75°. Spectra covering the range 1.9-14.4 µm with 1-2% resolution were acquired using circular variable interference filters. Although the data are nearly 30 years old, the longer wavelength data were acquired at a time when the atmosphere was relatively clear (estimated optical depth of 0.2 at 9 µm), in contrast to spectra obtained by the infrared spectrometer onboard Mariner 9. In addition, the spectral resolution is significantly higher than that obtained by the Viking IRTM.

We obtained a preliminary data set restoration from Martin [1] that updates the observation geometry to the current Martian coordinate system and provides a preliminary wavelength calibration. We have performed a radiometric calibration using preflight blackbody targets provided with the data set and measured inflight observations of the space background following the basic method outlined by Hanel et al. [2]. We also performed a more accurate wavelength calibration using atmospheric absorptions observed in the calibrated data. The calibrated data are consistent in the spectral regions of overlap and probably accurate to around 10%.

To date, we have completed the calibration of the dayside observations (approximately 92 spectra) for the wavelength range from 4.2 to 14.4 µm, including regions of varying albedo, elevation and latitude. In particular, for the wavelength range from 8 to 14.4 µm we note several absorptions attributed to CO_2 (also seen e.g. by Maguire [3]) and a broad absorption from 8 to 12 µm attributed to silicates. This latter absorption is primarily correlated to atmospheric pathlength and probably originates in atmospheric dust; however, variability of the surface emissivity is also possible. We also note a feature near 6.5 µm, that is currently unidentified, but correlates to atmospheric pathlength, suggesting an origin in atmospheric dust or other gaseous constituents, e.g. water. We have also examined spectra near the edge of the seasonal south polar cap for evidence of water and CO_2 clouds.

Sample Spectra:

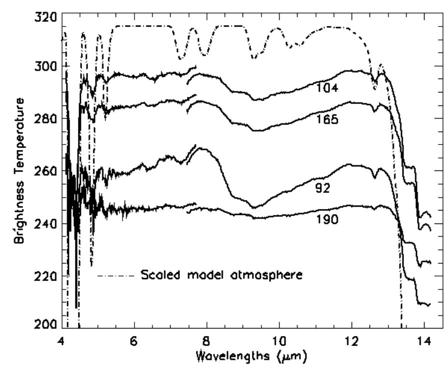

Figure 1. Here four Mariner spectra with varying viewing geometries and locations are compared with a model CO_2 atmosphere from Crisp [4], multiplied by 315. The model atmosphere has been convolved to the Mariner 7 resolution. We note there are small offsets in absolute radiance in the wavelength region of overlap (near 7.5 µm) but the slopes agree well and the offsets may just indicate the level to which we can believe the data are absolutely calibrated. A number of atmospheric CO_2 features are noted in the data set (4.2-4.4, <5, 5.2, 7.3, 12.6, and doublets near 9.4 and 10.5µm). Of interest are the features which are not readily attributed to CO_2 in the atmosphere, the broad absorption from 8 to 12 µm, and two features near 6.5 and 6.8 µm. Also of interest is the fact that a moderately strong absorption predicted to occur near 8 µm is not observed, either in Mariner 7 or in Mariner 9 average (see Figure 2). The 6.5 and 6.8 µm features are not observed in the Mariner 9 spectrum and may be related to atmospheric water. Alternatively, Pollack et al. [5] noted a feature at 6.7 µm that they attributed to carbonates or bicarbonates.

Since the Pollack et al. identification was made by calculating ratios of different spots on the planet, it is not clear if the features identified by Pollack et al. and those seen in the Mariner 7 data are the same. The Mariner 7 features are correlated to atmospheric pathlength, implying they are related either to the dust in the atmosphere or to another gaseous constituent not included in this model atmosphere.

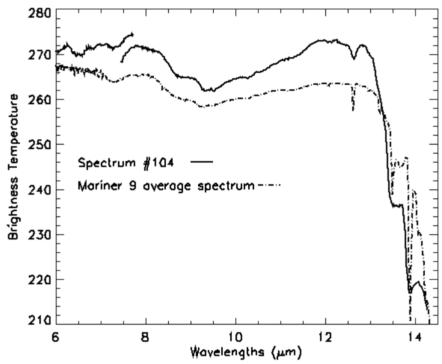

Figure 2. This figure compares the calibrated Mariner 7 spectrum #104 with an average from Mariner 9 provided by John Pearl (pers. comm., 1996). The Mariner 7 spectrum is the same than as in Figure 1, but reduced by 25K, for easier comparison. The Mariner 9 spectrum is an average of 1700 spectra taken after orbit #100, so that the dust had largely settled from the atmosphere. Emission angles were constrained to less than 60 degrees and Brightness Temperature to larger than 250K at 1300 cm^{-1} (7.69 μm) for the average. In general, there is very good agreement between the Mariner 7 and Mariner 9 spectra. In particular, we note in both the Mariner 7 and Mariner 9 spectra atmospheric absorptions at 7.3, 9.2 and 9.5, and 12.6 μm. A weak atmospheric doublet near 10.5 μm is also discernible, especially in spectra with long atmospheric pathlengths. An inflection near 11.5 μm is also noted in both Mariner 7 and 9 spectra and may also be associated with atmospheric dust as it is not predicted to be associated with atmospheric gases [e.g., 3,4]. The moderately strong feature near 6.5 μm and its weaker, narrower companion near 6.8 μm, are not seen in the Mariner 9 spectrum and are discussed with the previous figure.

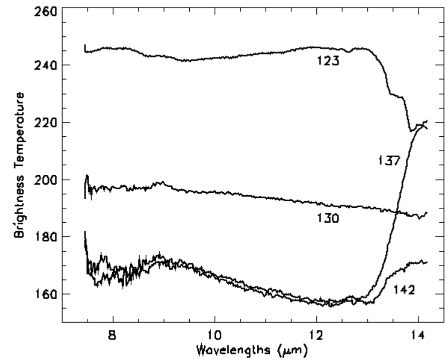

Figure. 3 Different spectra from the polar region are shown in this figure. Spectrum #123 observes only bare ground with no CO_2 frost, and its Brightness Temperature is the highest. Spectrum #130 is a transition zone, probably a mixed ground/CO_2 frost surface, and there are no evident spectral features. The disappearance of the strong atmospheric absorption >13 μm implies the ground and atmosphere are at roughly the same temperature. Spectra #137 and 142 are samples taken in an area of full CO_2 frost coverage. The inversion of the atmospheric features to emission peaks occurs because the surface is colder than the atmosphere. Variation in the strength of the 14 μm emission can be attributed to differences in atmospheric temperature, but may contain a contribution from surface frost grain size. Calvin and Martin [6] noted spatial variation in frost grain size based on the Mariner 7 data from 2-3.6 μm. We also note that the broad absorption from 8 to 10 μm also appears in emission, confirming the partial origin of this feature in atmospheric dust.

References:

[1] Martin, *BAAS*, *17*, p. 723, 1985.
[2] Hanel et al., *Exploration of the solar system by infrared remote sensing*, p. 259, 1992.
[3]Maguire, *Icarus, 32*, p. 85, 1977.
[4]Crisp, *JGR, 95*, p. 14577, 1990.
[5] Pollack et al., *JGR*, *95*, p. 14595, 1990.
[6] Calvin and Martin, *JGR, 99*, p. 21143, 1994.